Feasibility Study on Highly Distributed Lift Configurations

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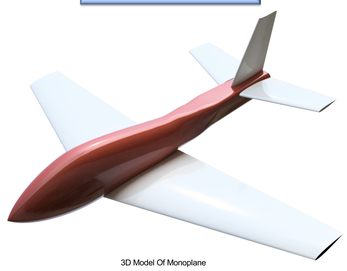
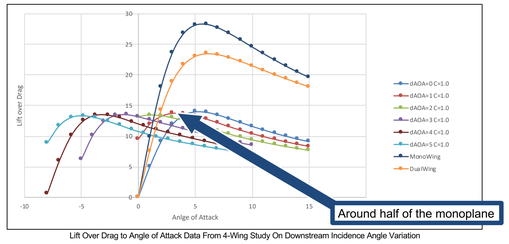
Problem



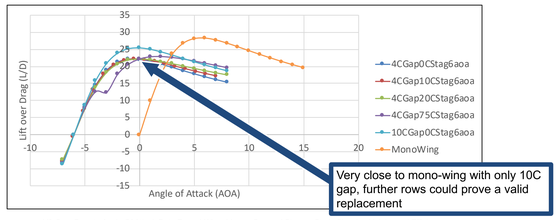
3D Model Of Monoplane

Current Monoplane Configurations:

- Are Less Maneuverable Than They Could Be
- Take Up A Lot Of Space Due To Long Wingspan
- Wings Are Significant Contribution To Aircraft Weight
- Wings Cost A Lot To Manufacture And Repair

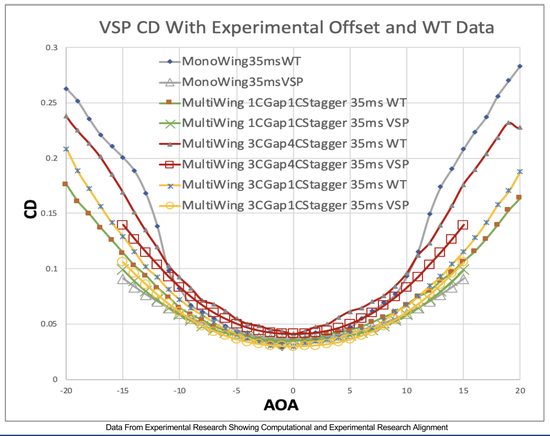


Lift Over Drag to Angle of Attack Data From 4-Wing Study On Downstream Incidence Angle Variation

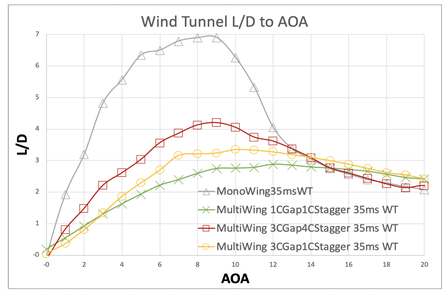


Lift Over Drag to Angle Of Attack Data From 4 Wing 4 Layer Gap and Stagger Study Showing Heightened Efficiency

Results



Data From Experimental Research Showing Computational and Experimental Research Alignment



Data From Experimental Research Showing Multi-wing Performance compared to Mono-wing Performance

- Agreement Of VLM Data And Experimental Data In Single Layer Configurations
- In Most Cases Increasing Gap And Stagger Improved L/D
- To Keep Design Compact, Configurations With Minimum Spacing Will Be Investigated

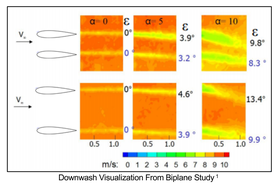
Proposed Solution

3D Model Of Multi-Wing

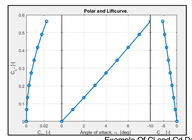
Reduce Span Size By 2 Orders Of Magnitude:

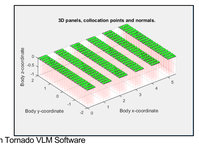
- Distributed Lift Across Numerous Smaller Wings
- Provide Much Greater Maneuverability
- Cost Less To Manufacture And Repair
- Are Considerably More Damage Tolerant

Previous Research

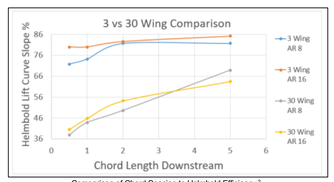


Downwash Visualization From Biplane Study [1]

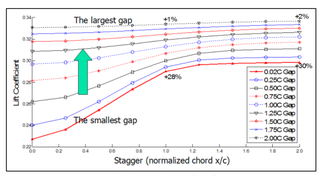




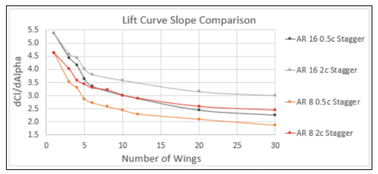
Example Of Cl and Cd Data From Tornado VLM Software



Comparison of Chord Spacing to Helmbold Efficiency [2]



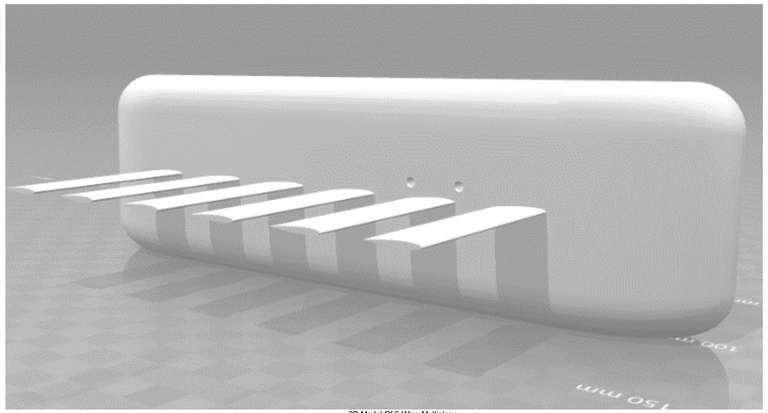
Results From Biplane Study [1]



Computational Results From Previous Multiplane Research [2]

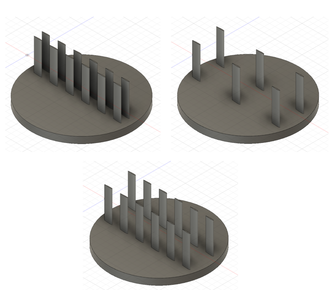
Wind Tunnel Testing Of 200 Winglet Multiplane

- Biplane Research Looked At The Effects Of Gap And Stagger On The Coefficient Of Lift (Cl)[1]
- Lower Lift From Lowering Aspect Ratio Negated With Increased Wing Count Downstream[2]
- Single Layer Multi-wing With Varied Stagger Focused On Cl To Angle Of Attack Relationship[2]

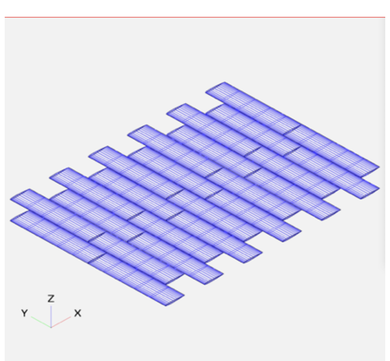


3D Model Of 6-Wing Multiplane

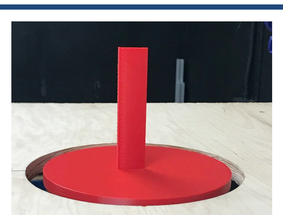
Methodology

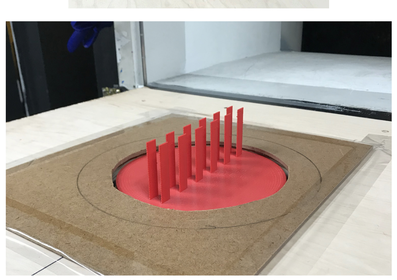


VSP Layout of 4-Wing Configuration



VSP Pressure Distribution Plot With Trailing Wakes





Wind Tunnel Testing Of 6 Wing Configuration

- Design Multi-wing Configurations With Same Overall Wing Area As Conventional Monoplane
- Use Vortex Lattice Method (VLM) Software To Model And Test For Cl And Cd At Angles Of Attack
- Goal Is Max L/D Of Multi-wing Close To That Of Monoplane
- Once Meaningful Results Are Found In VLM Software, 3D Models Tested In Wind Tunnel
- Test With Varying Span To Look At How Vorticity Effects L/D Of System, Increase Angle Of Attack Of Downstream Wings, And Vary Gap And Stagger Of Multilayer Wing Sets

Conclusions

- Variations In Downstream Incidence Angle And Span Did Not Show Results Close To That Of The Monoplane
- Single Layer Stagger Variation Around 75% Of Monoplane [2]
- 4 Layer Gap And Stagger In Configurations With Gaps Above 10C Show 90% Of Monoplane L/D
- The 4-wing Configuration Results Were Relevant In Software Modeling and Wind Tunnel Testing Verified These This But On A Smaller Scale.
- Meaningful Next Step Is Study Into Downstream Interactions On Wings And Effective L/D Changes Due To Interactions To Enable Increased Columns Of Gap And Stagger Wing Sets

Acknowledgements & References

1. Kang, H., Genco, N., Altman, A., *Gap and Stagger Effects on Biplanes with End Plates Part I*, **2009.**
2. Truszkowski, A., Altman, A., *Feasibility Study on Highly Distributed Lift Configurations*, **2018**.
3. Funding For This Portion Of Research Provided By University of Dayton Summer Undergraduate Research Experience